RIORDAN'S WELL G-E-M RESOURCES AREA

(GRA NO. NV-13)

TECHNICAL REPORT

(WSA NV 040-166)

Contract YA-553-RFP2-1054

Prepared By

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Final Report

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EXECUTIVE SUMMARY

The Riordan's Well Geology-Energy-Minerals (GEM) Resource Area (GRA) is a few miles southeast of Currant, in northeastern Nye County, Nevada. There is one Wilderness Study Area (WSA), NV 040-166, which is in the Grant Range.

Most of the rocks in the GRA are limestone and dolomite sediments ranging from about 300 million to 550 million years old. In the southern part of the GRA there is a body of intrusive granitic rocks about 150 million years old, and mineralization in the area is related to this intrusion. A small body of intrusive rock is known at one place in the WSA, but no others are known in the WSA.

The Troy mining district is in and beyond the southwest corner of the GRA. It has recorded production of about $1 million in gold and a moderate tonnage of tungsten ore. Tungsten is a strategic and critical mineral.

There are some patented claims in the Troy district, and many unpatented claims; some of the latter are very close to the southwest part of the WSA and a few apparently are within it. Small groups of unpatented claims are adjacent to the WSA at its southeast corner and northeast corner, and some claims of these groups may lie within the WSA. Another group of claims is adjacent to the west end of the WSA but apparently all lie outside it. Oil and gas leases cover about one-half of the WSA, but there are no geothermal leases. There are no sodium and potassium leases and no material sites in the WSA.

All of WSA NV 040-166 is classified as having low favorability with low confidence for metallic minerals and for uranium. The WSA has very low favorability with low confidence for thorium. Most of the WSA is classified as having moderate favorability with a moderate level of confidence for limestone and dolomite but much of the east edge and a small part of the west edge is classified as having moderate favorability with moderate confidence for sand and gravel. There is a low favorability with a low confidence level for oil and gas in the valley portions of the WSA, and no indication of favorability with a low confidence for the remaining part of the WSA. Geothermal favorability is low in a minor valley sector and no indication of favorability in most of the WSA -- both with a low confidence level.

Geological reconnaissance and geochemical sampling of the entire WSA is recommended; short of this, at least two structurally complex areas should be reconnoitered.

I. INTRODUCTION

The Riordan's Well G-E-M Resources Area (GRA No. NV-13) contains approximately 300,000 acres (1,200 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
Riordan's Well	NV 040-166

The GRA is located in Nevada in the Bureau of Land Management's (BLM) Egan Resource Area, Battle Mountain and Ely district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 38°36' north latitude 115°18' west longitude and includes the following townships:

T 9 N, R 57-60 E	T 7 N, R 57-60 E
T 8 N, R 57-60 E	T 6 N, R 57-60 E

The areas of the WSA are on the following U. S. Geological Survey topographic maps:

15-minute:

Currant	Forest Home

The nearest town is Currant which is located about four miles north of the northern GRA boundary at the intersection of U. S. Highway 6 and State Route 20. Access to the area is via U. S. Highway 6 to the northwest. Access within the area is via unimproved light duty and dirt roads scattered throughout the GRA.

Figure 2 outlines the boundaries of the GRA and the WSA on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report, following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with the corresponding age in years. This is so that the reader who is not familiar with geologic time subdivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin and Range province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin Booth III, and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

The WSA in this GRA was not field checked.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included in the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

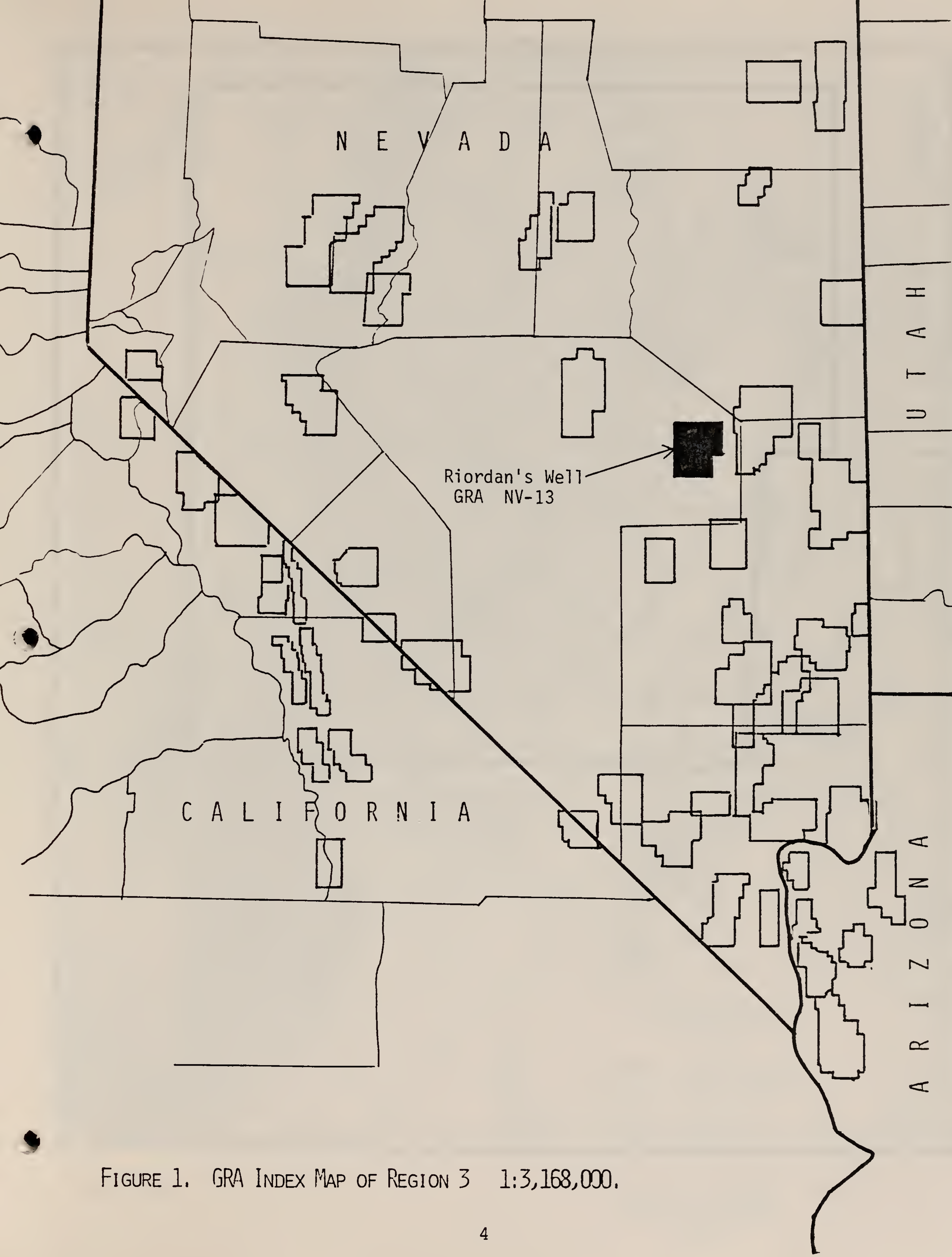
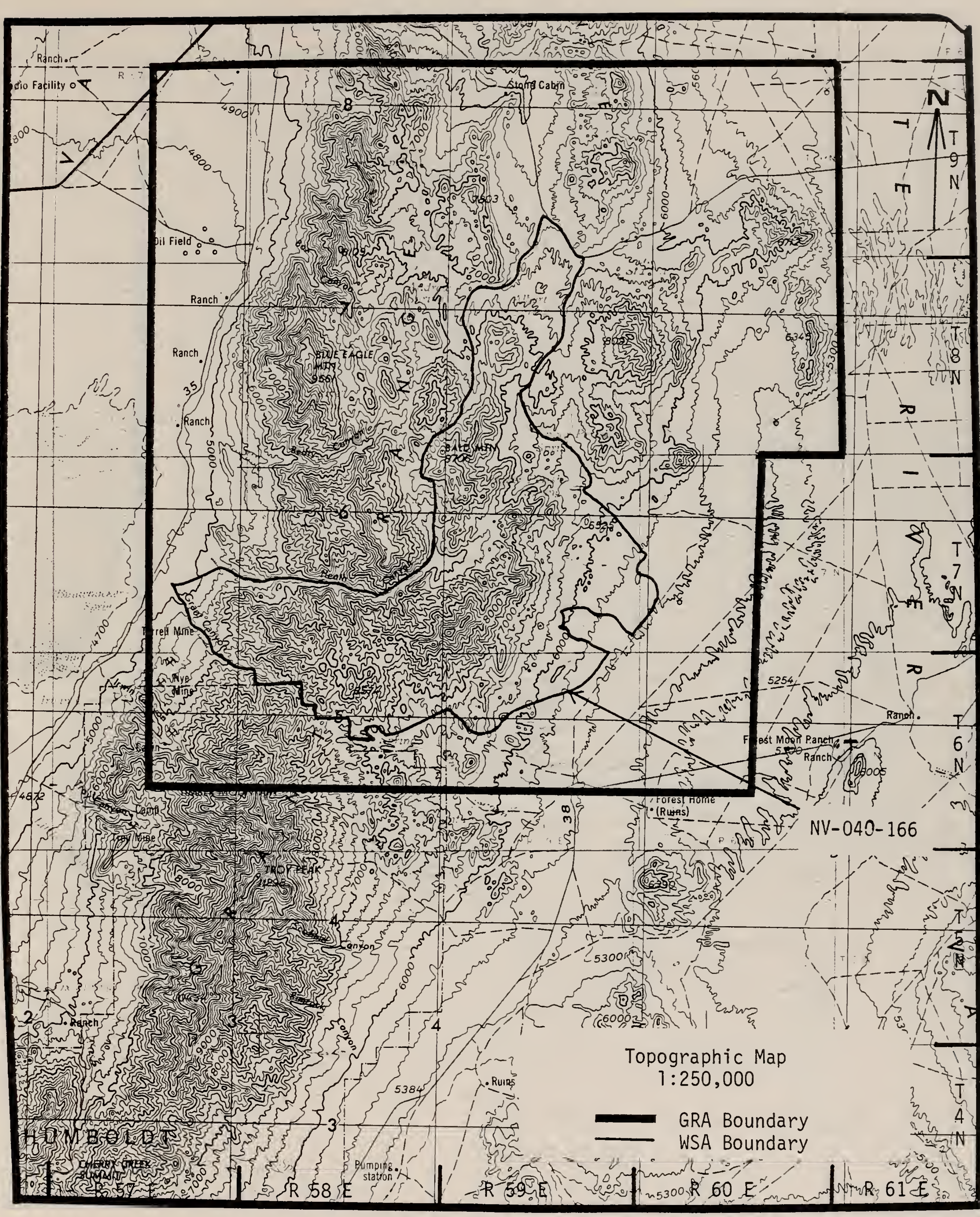
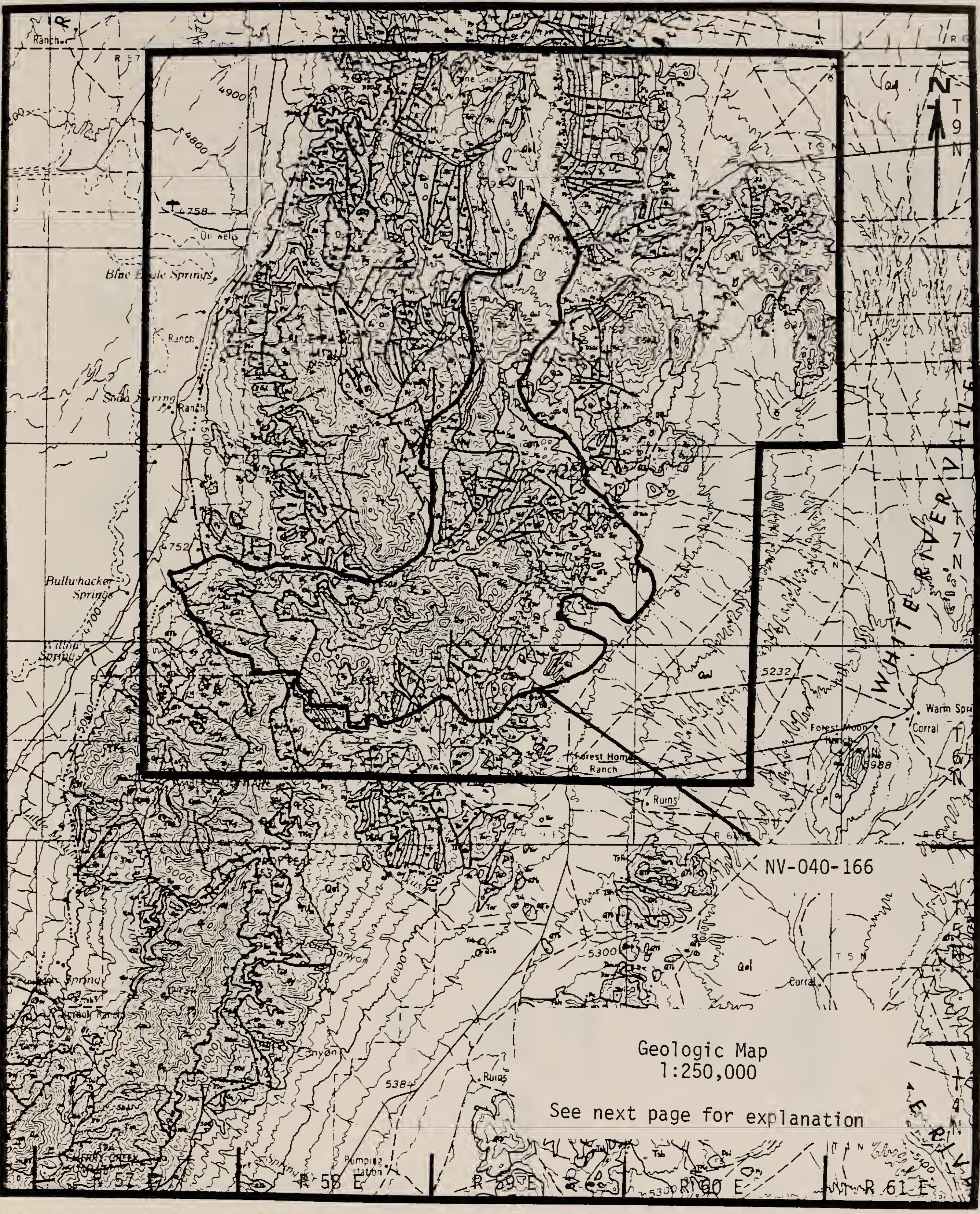


FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Lund Sheet

Riordan's Well GRA NV-13
Scale 1:250,000
Figure 2



Kleinhampl and Ziony (1967)

Riordan's Well GRA NV-13
Scale 1:250,000
Figure 3

Preliminary Geologic Map of Northern Nye County, Nevada

by

Frank J Kleinhampl & Joseph I. Ziony

EXPLANATION

QUATERNARY — Pleistocene and Recent

Qal — Alluvium. Fan and stream gravels flanking mountains and grading into sand and silt in valleys. Includes terraces

Qls — Landslide deposits

Qm — Morainal deposits. Restricted to Toiyabe and Toquima Ranges

Qtf — Calcareous tufa. In aprons and around orifices of springs

Monte Cristo Mountains, Paradise Range, Shoshone Mountains, Royston Hills, Toiyabe Range & San Antonio Mountains

Toquima Range

Monitor, Antelope, Hot Creek, Kawich, & Reveille Ranges

Pancake, White Pine, Horse, Grant, Quinn Canyon, Golden Gate, Egan, and South Egan Ranges

Qb, Qbc, Qba — Basaltic Rocks. Qb, basalt in flows. Qbc, basaltic scoria in cones and mounds. Qba, basaltic ash and scoria

TERTIARY OR QUATERNARY — Pliocene or Pleistocene

Monte Cristo Mountains, etc.: **QTb** — Basalt and andesite

Toquima Range: **QTb** — Basalt and andesite

Monitor, Antelope, etc.: **QTb** — Basalt and andesite

Pancake, White Pine, etc.: **QTb** — Basalt, andesite, and latite

TERTIARY — Miocene or Pliocene

Monte Cristo Mountains, etc.:

Tl — Quartz latite in flows and plugs. Includes Brougher Dacite (Radiometric age 16.3 m.y. ①)

Tyr — Younger rhyolite in flows, plugs, and dikes. Includes Oddie Rhyolite

Td — Dacite porphyry

Tts — Tuff, tuffaceous shale, and diatomite

Toquima Range:

Tyr — Younger rhyolite in plugs and dikes

Monitor, Antelope, etc.:

Tyr — Younger rhyolite in domes, plugs, and flows

Td — Rhyodacitic to quartz latitic porphyry in stocks, plugs, and dikes

Pancake, White Pine, etc.:

Tyr — Rhyolitic to latitic flows and plugs

Td — Rhyodacitic to quartz latitic porphyry in stocks, plugs, and dikes

Thc — Horse Camp Formation of Moores, 1964. Conglomerate, siltstone, and monolithic breccia and landslide masses

TERTIARY — Miocene

Monte Cristo Mountains, etc.:

Tf — Fraction tuff. Lithic-rich welded ash-flow tuff. Radiometric age: 17.5 m.y. ①

Twt — Welded ash-flow tuffs of Toiyabe Range. Includes andesite flows in southern Shoshone Range. Equivalent to Toiyabe Quartz Latite. Radiometric age: 21.5 to 23.1 m.y. ①

Toquima Range:

Tf — Fraction tuff. Lithic-rich ash-flow tuff

Tmd — Tuffs of Meadow Creek. Welded and non-welded ash-flow tuffs

Tj — Tuffs of Mount Jefferson. Moderately crystal-rich ash-flow tuff. Radiometric age: 24.7 to 26.1 m.y. ①

Monitor, Antelope, etc.:

Tf — Tuffs probably correlative with Fraction Tuff. Lithic-rich welded ash-flow tuff, rhyodacitic to quartz latitic in composition.

Twh — Tuffs probably correlative with tuffs of White Blotch Spring of southern Nye County

Tsh — Shingle Pass(?) Tuff. Chiefly crystal-deficient welded ash-flow tuffs, includes tuffaceous sediments at base

Pancake, White Pine, etc.:

Tsh — Shingle Pass Tuff. Crystal deficient welded ash-flow tuff. Radiometric age: [illegible] to 25.4 m.y. ①② Locally includes Needles Range(?) Formation

TERTIARY — (?)

Monitor, Antelope, etc.:

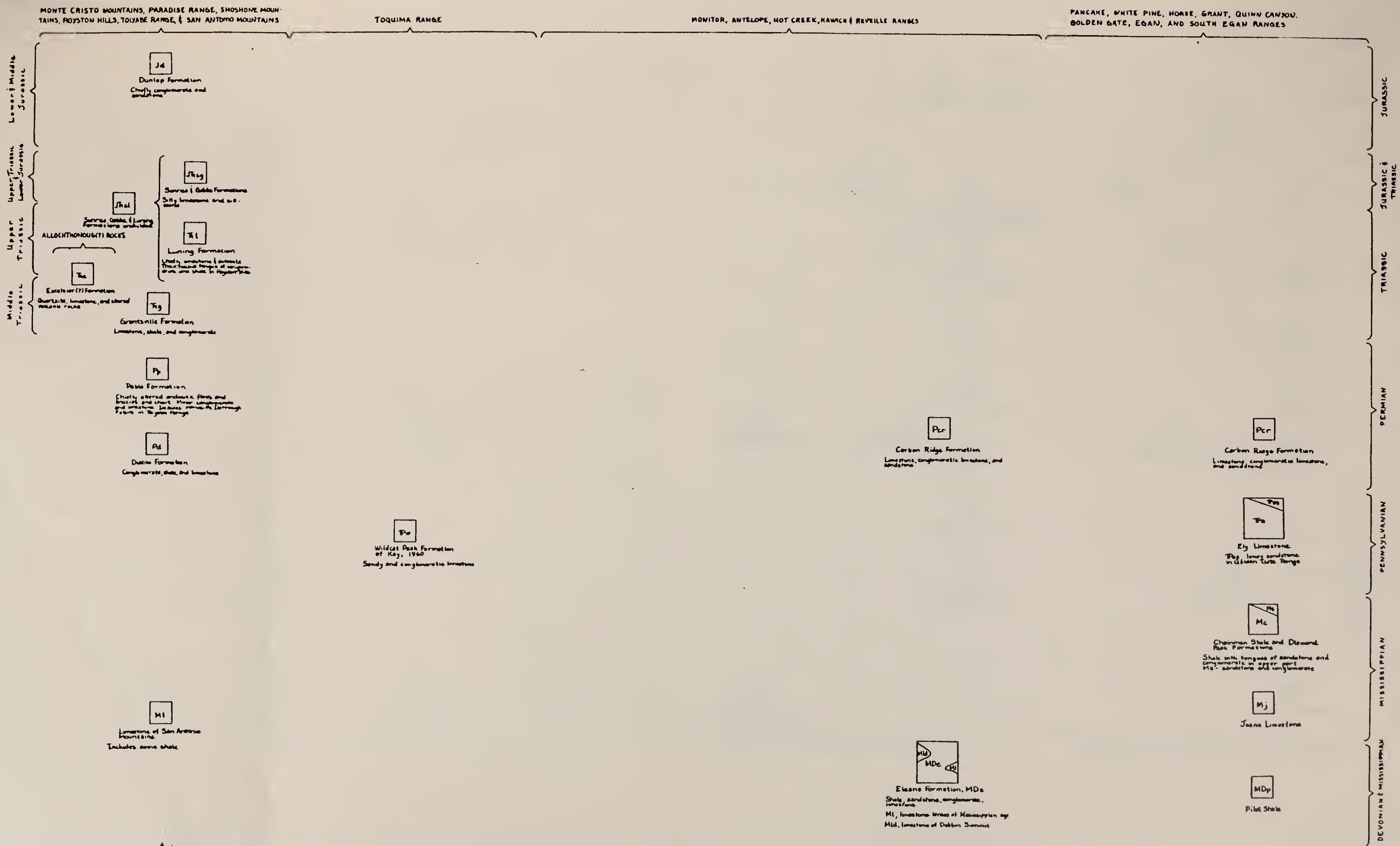
Tm — Tuffs of Monotony Valley of southern Nye County. Mafic- and crystal-rich welded ash-flow tuffs. Radiometric age 26.5 m.y. ①

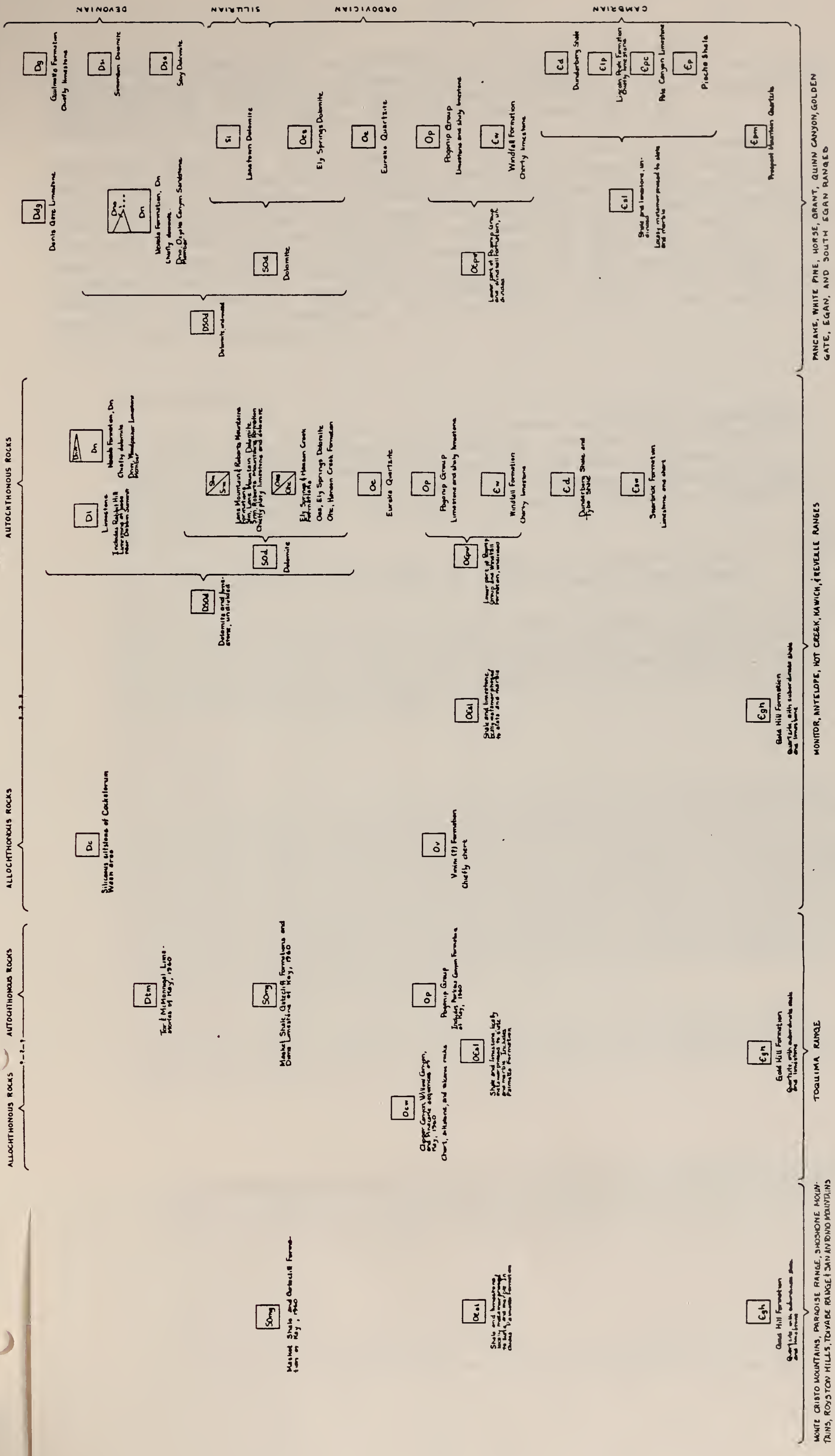
Pancake, White Pine, etc.:

Tm — Tuffs of Monotony Valley of southern Nye County. Mafic- and crystal-rich welded ash-flow tuffs

Age	Monte Cristo Mountains, Paradise Range, Shoshone Mountains, Royston Hills, Toiyabe Range, and San Antonio Mountains	Toquima Range	Monitor, Antelope, Hot Creek, Kawich, & Reveille Ranges	Pancake, White Pine, Horse, Grant, Quinn Canyon, Golden Gate, Egan, and South Egan Ranges
Oligocene and Oligocene(?)	Tvm, Ta — Middle volcanic sequence. Chiefly lithic-rich air-fall tuff. Includes rhyolite flows in Shoshone Mountains, and conglomerate in southern Toiyabe Range. Ta, andesite flows Tan — Andesite, commonly altered and mineralized. Includes Mizpah Trachyte Tto — Tonopah Formation. Welded ash-flow tuff, commonly altered and locally mineralized; tuffaceous sedimentary rocks; and conglomerate Tvl — Lower volcanic sequence of western ranges. Pumice-rich welded ash-flow tuff in northern Shoshone Mountains. Rhyolitic to andesitic flows, and welded ash-flow tuffs, all commonly altered and mineralized, in southern Shoshone Mountains and southern Paradise Range	Tvm, Ta — Middle volcanic sequence, Tvm. Chiefly lithic-rich air-fall tuff. Ta, andesite flows, dikes, and sills Tmc — Tuffs of Moores Creek. Welded ash-flow tuffs and air-fall and water-laid tuffs west of Northumberland Canyon, upper part contains landslide masses and chaotic breccia of chert	Th, Ta — Volcanic rocks of Hannapah mining district and Saulsbury Wash. Welded ash-flow tuffs, tuffaceous sedimentary rocks, and dacitic to andesitic flows and dikes in a vent complex. Ta, andesite where mapped separately Twa, Ts, Ta — Volcanic rocks. Twa, chiefly crystal-rich welded ash-flow tuffs. Radiometric age [illegible] m y. Ts, tuffaceous and clastic sedimentary rocks, includes pumice-flow breccia [illegible] of Hunts Canyon. Ta, andesite in flows Toa, Tol, Tor — Older volcanic flows. Toa, andesite; Tol, latite; Tor, rhyolite	Ts, Tws, Ta, Tnr, Twb, Tsc, Tcw — Volcanic rocks. Tws, chiefly crystal-rich welded ash-flow tuffs. Tnr, Needles Range(?) Formation. Radiometric age 29 m y. Twb, Windous Butte Tuff of Cook, 1960. Radiometric age 32.0 m y. Tsc, Stone Cabin Tuff of Cook, 1960. Tcw, Calloway Well Formation of Scott, 1965a. Ts, tuffaceous and clastic sedimentary rocks. Ta, andesite in flows Tol, Tor — Older volcanic flows. Tol, latite; Tor, rhyolite and dacite. Radiometric age of rhyolite east of Currant: 36 m y
Eocene			Tg — Gilmore Gulch Formation. Shale, sandstone and limestone	Tsp — Sheep Pass Formation. Conglomerate overlain by lacustrine limestone and shale
Cretaceous(?) and Tertiary	Granitic and rhyolitic to basaltic dikes and sills	Rhyolitic to basaltic dikes and sills	Rhyolitic to basaltic dikes and sills	Granitic and rhyolitic to basaltic dikes and sills
Cretaceous or Tertiary		TKc — Conglomerate	TKs — Sedimentary rocks	TKc, TKt, TKl — Sedimentary rocks. TKc, conglomerate; TKt, tuff; TKl, limestone TKg — Granitic rocks. Chiefly quartz monzonite. Radiometric age of stock at Troy Canyon in Grant Range 20 m y. Radiometric ages of stocks in White Pine Range 31 m y and 36 m y
Lower Cretaceous (Cretaceous)			Knc — Newark Canyon Formation. Sandstone, shale, and conglomerate	Knc — Newark Canyon Formation. Sandstone, shale, and conglomerate
Cretaceous(?)	Kg, Kd — Plutonic rocks. Kg, granitic rocks, including quartz monzonite and granodiorite. Kd, dioritic rocks, including gabbro	Kg, Kgp, Kd — Plutonic rocks. Kg, granitic rocks, including quartz monzonite and granodiorite. Mapped granitic porphyry, Kgp. Kd, dioritic rocks, including quartz diorite. Radiometric age of pluton east of Round Mountain: 78 to 107 m y	Kg — Plutonic rocks. Granodiorite(?) in southern Monitor Range	

	MONITOR, ANTELOPE, HOT CREEK, KAWICH & REVEILLE RANGES	PANCAKE, WHITE PINE, HORSE, GRANT, QUINN CANYON, GOLDEN GATE, EGAN, AND SOUTH EGAN RANGES
JURASSIC		
JURASSIC & TRIASSIC		
TRIASSIC		
PERMIAN	Pcr Carbon Ridge Formation Limestone, conglomeratic limestone, and sandstone	Pcr Carbon Ridge Formation Limestone, conglomeratic limestone, and sandstone
PENNSYLVANIAN		Pe, Pes Ely Limestone Pes, limey sandstone in Golden Gate Range
MISSISSIPPIAN		Mc, Ms Chainman Shale and Diamond Peak Formations Shale with tongues of sandstone and conglomerate in upper part Ms - sandstone and conglomerate Mj Joana Limestone
DEVONIAN & MISSISSIPPIAN	MDe, Ml, Mld Eleana Formation, MDe Shale, sandstone, conglomerate, limestone Ml, limestone lenses of Mississippian age Mld, limestone of Dobbin Summit	MDp Pilot Shale


MONTE CRISTO MOUNTAINS, PARADISE RANGE, SHOSHONE MOUNTAINS, ROYSTON HILLS, TOIYABE RANGE, & SAN ANTONIO MOUNTAINS
TOQUIMA RANGE
MONITOR, ANTELOPE, HOT CREEK, KAWICH & REVEILLE RANGES
PANCAKE, WHITE PINE, HORSE, GRANT, QUINN CANYON, GOLDEN GATE, EGAN, AND SOUTH EGAN RANGES
Lower & Middle Jurassic
Upper Triassic & Lower Jurassic
Upper Triassic
Middle Triassic
JURASSIC
JURASSIC & TRIASSIC
TRIASSIC
PERMIAN
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN & MISSISSIPPIAN
Jd
Dunlap Formation
Chiefly conglomerate and sandstone
ALLOCHTHONOUS(?) ROCKS
Excelsior (?) Formation
Quartzite, limestone, and altered volcanic rocks
Grantsville Formation
Limestone, shale, and conglomerate
Luning Formation
Sunrise & Gabbs Formations
Silty limestone and siltstone
Pablo Formation
Pd
Diablo Formation
Conglomerate, shale, and limestone
Ml
Limestone of San Antonio Mountains
Includes some shale
Wildcat Peak Formation of Kay, 1960
Sandy and conglomeratic limestone
Pcr
Carbon Ridge Formation
Limestone, conglomeratic limestone, and sandstone
Ely Limestone
Mc
Chainman Shale and Diamond Peak Formations
Shale with tongues of sandstone and conglomerate in upper part
Mj
Joana Limestone
MDe
Eleana Formation, MDe
Shale, sandstone, conglomerate, limestone
Ml, limestone lenses of Mississippian age
Mld, limestone of Dobbin Summit
MDp
Pilot Shale


DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
ALLOCHTHONOUS ROCKS
AUTOCHTHONOUS ROCKS
Dg
Guilmette Formation
Chiefly limestone
Ds
Simonson Dolomite
Dse
Sevy Dolomite
Ddg
Denay Creek Limestone
Dn
Nevada Formation, Dn
Chiefly dolomite
DSOd
SOd
Dolomite
Sl
Laketown Dolomite
Oes
Ely Springs Dolomite
Oe
Eureka Quartzite
Op
Pogonip Group
Limestone and shaly limestone
Ꞓw
Windfall Formation
Cherty limestone
OꞒpw
Ꞓd
Dunderberg Shale
Ꞓlp
Ꞓpc
Pole Canyon Limestone
Ꞓp
Pioche Shale
Ꞓsl
Shale and limestone, undivided
Locally metamorphosed to slate and marble
Ꞓpm
Prospect Mountain Quartzite
PANCAKE, WHITE PINE, HORSE, GRANT, QUINN CANYON, GOLDEN GATE, EGAN, AND SOUTH EGAN RANGES
Dl
Limestone
Dc
Siliceous siltstone of Cockalorum Wash area
Dolomite and limestone, undivided
Oe
Eureka Quartzite
Op
Pogonip Group
Limestone and shaly limestone
Ꞓw
Windfall Formation
Cherty limestone
Ꞓd
Dunderberg Shale and Tybo Shale
Ꞓsw
Swarbrick Formation
Limestone and chert
Ov
Vinini (?) Formation
Chiefly chert
OꞒsl
Shale and limestone, locally metamorphosed to slate and marble
Ꞓgh
Gold Hill Formation
Quartzite, with subordinate shale and limestone
MONITOR, ANTELOPE, HOT CREEK, KAWICH, & REVEILLE RANGES
Dtm
Tor & McMonnigal Limestones of Kay, 1960
SOmg
Masket Shale, Gatecliff Formations and Diana Limestone of Kay, 1960
Op
Pogonip Group
OꞒsl
Ocw
Clipper Canyon, Willow Canyon, and Pinecone sequences of Kay, 1960
Chert, siltstone, and siliceous rocks
Ꞓgh
Gold Hill Formation
Quartzite, with subordinate shale and limestone
TOQUIMA RANGE
SOmg
Masket Shale and Gatecliff Formation of Kay, 1960
OꞒsl
Ꞓgh
Gold Hill Formation
MONTE CRISTO MOUNTAINS, PARADISE RANGE, SHOSHONE MOUNTAINS, ROYSTON HILLS, TOIYABE RANGE & SAN ANTONIO MOUNTAINS

II. GEOLOGY

The Riordan's Well GRA is located in the Basin and Range geomorphic province in northeastern Nye County, Nevada. The study area includes a portion of the northerly-trending Grant Range and adjacent portions of White River and Railroad Valleys.

The Grant Range is an eastward-tilted fault block of Paleozoic sediments that have been locally overlain by Tertiary sediments and volcanic sequences. Structure in the area is complex and the ages of tectonic events has been described only in broad ranges. Mesozoic thrusting and faulting, followed by Tertiary warping and Basin and Range faulting have transected and displaced the Paleozoic sediments. Much of the geology in the GRA has been described in masters theses by Kirkpatrick (1960), Hyde (1963) and Huttrer (1963) who described the northern, central, and southern Grant Range, respectively.

1. PHYSIOGRAPHY

The Riordan's Well GRA is in the Basin and Range geomorphic province in northeastern Nye County, Nevada. WSA 040-166 covers a crescent shaped portion of the Grant Range, a northerly-trending fault block of Paleozoic sediments that have been complexly thrusted, faulted and locally overlain by Tertiary volcanics.

The topography of the range is rugged with elevations of peaks averaging about 8,500 feet and the valleys 5,000 feet.

Drainage of the area is internal with streams flowing from the western side of the range discharging into Railroad Valley. The eastern side of the range drains into the White River, which flows south into Upper Pahranagat Lake several miles south of the town of Alamo.

2. ROCK UNITS

The oldest rock unit in the study area is the Lower Cambrian Prospect Mountain Quartzite which consists of pinkish to olive green quartzite that forms massive beds from six inches to eight feet thick. The Pioche Shale, a sequence of interbedded silty shale and clay shale with minor interbeds of crossbedded sandstone, was deposited next. The Middle Cambrian Geddes Limestone is the next youngest formation, which is overlain by the Secret Canyon Shale. Undifferentiated Upper Cambrian shales and limestones have been mapped by Huttrer (1963) as the next youngest formation.

The Ordovician Pogonip group, a sequence of platy to thin bedded, medium gray detrital limestones was deposited during the early Ordovician. The Leyman Limestone (Huttrer, 1963)

and Kanash Shale (Kirkpatrick, 1960) were laid down next, and in turn were overlain by the cliff-forming Eureka Quartzite. The Ely Springs Dolomite, which usually forms a series of slopes and ledges, was deposited next during the Upper Ordovician.

The Laketown Dolomite, a fine grained dolomite that weathers olive-gray, is the only formation deposited during the Silurian.

The Lower Devonian Sevy Dolomite, together with the overlying Simonson Dolomite, form a distinctive, uniform, and persistent stratigraphic unit that was studied in detail by Osmond (1954, 1962). The Guilmette Formation, a predominantly even-bedded dark gray sublithographic limestone, was deposited next during Middle Devonian time.

According to Kirkpatrick (1960) the Devonian-Mississippian Pilot Shale occurs along a very narrow zone on the eastern flank of the main ridge of the northern Grant Range. Moores and others (1968) and Huttrer (1963) indicate that the Pilot Shale is absent from the northern Grant Range due to Late Devonian-Early Mississippian upwarping in the area.

The Mississippian-Pennsylvanian Chainman Shale, consisting of dark gray to black shale and olive-gray siltstone or silty shale, was deposited next and was overlain by the Diamond Peak Formation, a sequence of siltstone, claystone, and minor sandstone and conglomerate.

The Pennsylvanian Ely Limestone is the youngest Paleozoic unit mapped in the area by Huttrer (1963), Hyde (1963), and Kirkpatrick (1960). No Mesozoic sediments have been identified in the GRA.

Granitic intrusions in the southwest part of the GRA may have been emplaced during the late Mesozoic (Huttrer, 1963). Huttrer (1963) mapped a dike in Heath Canyon, at the edge of the WSA, but Kleinhampl and Ziony (1967), Hyde (1963) and Kirkpatrick (1960) show no intrusive rocks anywhere in the WSA. An unnamed conglomerate unit was deposited sometime during the Early Tertiary. The Eocene Sheep Pass Formation, which consists of a basal breccia overlain by interbedded lacustrine limestone, sandstone, and siltstone, was deposited next.

A sequence of older volcanic rocks deposited mostly during the Early Eocene unconformably overlie the Sheep Pass Formation. This series of volcanics crops out along the eastern flank of the Grant Range and consists of welded tuffs, flows and breccias of dacite, andesite and rhyolite.

An olivine basalt deposited during the Quaternary is the youngest volcanic unit in the study area and occurs east of Bald Mountain.

3. STRUCTURAL GEOLOGY AND TECTONICS

The structure in the Riordan's Well GRA is extremely complex and the historical sequence of tectonic events is not completely understood. High angle faulting, both normal and reverse, as well as thrusting and folding have deformed the Paleozoic sediments.

Misch (1960) states that the major orogeny in this area occurred in mid-Mesozoic time prior to the Laramide interval. The orogeny included an earlier phase associated with low-grade regional metamorphism and a later phase characterized by eastward thrusting of Paleozoic sediments. The Grant Canyon, Heath Canyon and Beaty Canyon thrusts in the southwest portion of the study area have been described in detail by Huttrer (1963) and Hyde (1963). The Blue Eagle and Cave Canyon thrusts in the northwestern part of the GRA have been described by Kirkpatrick (1960).

The upper plates of the above mentioned thrusts are gently warped and are cut by high angle faults. The upper plate of the Beaty Canyon thrust forms a broad asymetrical syncline and the upper plate of the Grant Canyon thrust has several gentle folds. Both high-angle faulting and broad gentle folding are generally assigned to the Cenozoic (Huttrer, 1963).

High-angle normal faults along the eastern side of the range may have formed along a northerly-trending flexure line (Huttrer, 1963). The alignment of springs on the west side of the range and truncation of the internal structures in the range suggest a western range front fault. Numerous northerly-trending high-angle faults, both normal and reverse, transect the Paleozoic sediments. Most of these faults are post-thrusting, but several faults of minor displacement have been dated as pre-thrusting by Hyde (1963).

4. PALEONTOLOGY

Search of available literature indicates that no specific localities of paleontological resources lie within the boundary of the Riordan's Well GRA. However, Paleozoic marine strata, ranging in age from Cambrian to Mississippian, have suitable lithologies for the preservation of fossils and the possibility of their occurrence is to be considered high.

Tertiary lacustrine sediments within the GRA are not known to be fossiliferous, although similar units north of the study area have yielded nonmarine mollusks (Firby, 1973).

5. HISTORICAL GEOLOGY

The deposition of eastern facies miogeosynclinal rocks proceeded uninterruptedly from the Cambrian to the Devonian. An interruption in sedimentation is marked by the absence of the Pilot Shale in this area. This may be attributed to a Late Devonian-Early Mississippian north-south trending upwarp extending south from the White Pine Mountains at least as far as the Quinn Range, and might be related to the Antler Orogeny further west (Roberts, 1949; Roberts, and others, 1958). Subsequently, sedimentation continued through the Pennsylvanian.

A major orogeny, including an earlier phase associated with low grade regional metamorphism and a later phase characterized by eastward thrusting, probably occurred during mid-Mesozoic time.

Thick clastic sediments accumulated during the Early Tertiary followed by the extrusion of welded tuffs, flows, and breccias of dacite, andesite and rhyolite. Basin and Range faulting and gentle folding of the upper thrust plates occurred sometime during the Late Tertiary.

Volcanism was reactivated during the Quaternary with the extrusion of olivine basalt.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

In and beyond the southwest corner of the GRA is the Troy district, which has produced some gold. The northern part of the district, within a mile of WSA NV 040-166, has produced an unknown amount of tungsten from the Nye and Terrell and perhaps other mines (Kleinhampl and Ziony, 1980).

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Kral (1951) reports lead-silver occurrences, and a manganese occurrence, in Grant Canyon. His report evidently was written before tungsten discoveries were made in the area, and it may be that the prospects he writes of later became tungsten producers. If so, they are all outside the WSA. The Troy Canyon and Forest Home fifteen-minute topographic quadrangles do not show any mine or prospect symbols in Grant Canyon itself; the ones they do show are all south of the Canyon and outside the WSA.

Texasgulf Western sampled the Well claim group in Sec. 25, T 9 N, R 59 E (unsurveyed) close to the northern tip of the WSA and concluded the property has moderate exploration potential for a disseminated gold deposit, but did not pursue exploration here (see notes in GRA file).

3. Mining Claims

There are numerous unpatented claims, many of them in the Troy district, the northernmost of which plot as lying within the southwest corner of the WSA. Several miles east of here, on the east side of the Grant Range, another group of claims lies adjacent to the WSA. Some of the claims plot within the WSA. At the north tip of the WSA is the Well group of claims described above; some of these claims plot within the WSA. On the southwest side of the WSA, a group of claims on the north side of Heath Canyon is adjacent to the WSA but none of the claims plot within it.

4. Mineral Deposit Types

The tungsten deposits are contact metamorphic deposits, almost certainly related to the Tertiary granitic body (Kleinhampl and Ziony, 1980) that is exposed southwest of

the GRA between Irwin and Troy Canyons. No intrusive rocks are known in the WSA or closer to it than this one.

The gold produced from the Troy district was in quartz veins in both intrusive rocks and sediments (Kral, 1951). These, too, probably are genetically related to the intrusive, as well as are the lead-silver and manganese occurrences mentioned by Kral (1951).

5. Mineral Economics

If tungsten deposits similar to those mined in the past are discovered, they almost certainly will be mined during times of high tungsten prices but probably not during most periods when prices are lower.

Gold veins such as have been mined in the past are of minimal interest to major mining companies but can be mined profitably by small organizations. The rock types are suitable for large low-grade gold deposits, however, which would be of interest to large companies.

The major use of gold is for storing wealth. It is no longer used for coinage because of monetary problems, but many gold "coins" are struck each year for sale simply as known quantities of gold that the buyer can keep or dispose of relatively easily. The greatest other use of gold is in jewelry, another form of stored wealth. In recent years industrial applications have become increasingly important, especially as a conductor in electronic instrumentation. In the United States and some other countries gold is measured in troy ounces that weigh 31.1 grams -- twelve of which make one troy pound. Annual world production is about 50 million ounces per year, of which the United States produces somewhat more than one million ounces, less than one-fourth of its consumption, while the Republic of South Afric is by far the largest producer at more than 20 million ounces per year. World production is expected to increase through the 1980s. For many years the price was fixed by the United States at $35 per ounce, but after deregulation the price rose to a high of more than $800 per ounce and then dropped to the neighborhood of $400 per ounce. At the end of 1982 the price was $460.50 per ounce.

The major uses of silver are in photogrpahic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1 grand grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds

of all silver is produced as a by-product in the mining of other metals, so the supply cannot readily adjust to demand. It is a strategic metal. Demand is expected to increase in the next decades because of growing industrial use. At the end of 1982 the price of silver was $11.70 per ounce.

More than half of all tungsten used is in the form of tungsten carbide, a hard and durable material used in cutting tools, wear-resistant surfaces and hard-faced welding rods. Lesser quantities are used in alloy steels, in light bulb filaments, and in chemicals. World production of tungsten is nearly 100 million pounds annually, of which the United States produces somewhat more than six million pounds, while using more than 23 million pounds. The shortfall is imported from Canada, Bolivia, Thailand and Mainland China, as well as other countries. Tungsten is a strategic and critical metal. United States demand is projected to about double by the year 2000, and most of the additional supply will probably be imported, because large reserves are in countries in which profitability is not a factor -- they need foreign exchange, and therefore sell at a price that few domestic mines can match. Tungsten prices F.O.B. mine are quoted for "short ton units", which are the equivalent of 20 pounds of contained tungsten. At the end of 1982 the price of tungsten was about $80 per short ton unit.

B. NONMETALLIC MINERAL DEPOSITS

1. Known Mineral Deposits

There are no known nonmetallic mineral deposits in WSA NV 040-166.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Most of the rocks in the WSA are Paleozoic limestones or dolomites, which are considered nonmetallic minerals since very large quantities of limestone and dolomite are mined annually in the United States for industrial use.

Part of the eastern edge of the WSA, and a small segment of the western edge, extend beyond bedrock to cover Quaternary alluvium which contains sand and gravel.

3. Mining Claims, Leases and Material Sites

No mining claims can be identified as having been located for nonmetallic minerals. There are no mineral leases and no material sites in the WSA.

4. Mineral Deposit Types

The limestones and dolomites are sedimentary beds, and thus can be expected to be very extensive and to be fairly uniform in quality along individual units.

The Quaternary alluvium is mostly sand and gravel, of unknown quality.

5. Mineral Economics

Since limestone and dolomite are low unit price commodities, they must be mined and processed close to the point where they are to be used, or at least they must have inexpensive haulage to the point of use. The isolated location of the Grant Range, then, dictates that these rocks will not be mined in the near future.

Sand and gravel are low unit cost materials, seldom transported more than a few miles from the mine to the point of use. The only likely use for these materials in the Grant Range is on nearby highway construction -- if there should be any highway construction nearby.

Pure limestone and dolomite are used principally to produce lime, but some is used as rock for building stone, crushed rock, and similar applications. The principal uses of lime are in steel smelting, water purification, as an alkali, in paper and pulp manufacture, and sewage treatment. Other uses for lime are in sugar purification, mortar, and as an agricultural soil conditioner. Limestone with certain clay impurities (called cement rock), or purer limestone with clay added, is used to make cement that is mostly consumed in construction. The United States uses about 20 million tons of lime and 85 million tons of cement annually. For both lime and cement the raw material must be mined within a very few miles of the processing plant, because it has a very low value in the form of run-of-mine rock -- two or three dollars per ton. There are numerous lime and cement plants in the United States, and most of them sell most of their product within a 200-mile radius of the plant. Some cement is imported in the form of clinker, which is the kiln-fired rock that is then ground in the United States. In the early 1980s the price F.O.B. plant of both lime and cement is about $40 per ton.

The most common use of sand and gravel is as "aggregate" -- as part of a mixture with cement to form concrete. The second largest use is as road base, or fill. About 97 percent of all sand and gravel used in the United States is in these applications in the construction industry. The remaining three percent is used for glassmaking, foundry sands, abrasives, filters and similar

applications. The United States uses nearly one billion tons of sand and gravel annually, all of it produced domestically except for a very small tonnage of sand that is imported for highly specialized uses. Since construction is by far the greatest user of sand and gravel, the largest production is near sites of intensive construction, usually metropolitan areas. Since sand and gravel are extremely common nearly everywhere, the price is generally very low and mines are very close to the point of consumption -- within a few miles as a rule. However, for some applications such as high-quality concrete there are quite high specifications for sand and gravel, and acceptable material must be hauled twenty miles and more. Demand for sand and gravel fluctuates with activity in the construction industry, and is relatively low during the recession of the early 1980s. Demand is expected to increase by about one third by the year 2000. In the early 1980s the price of sand and gravel F.O.B. plant averaged about $2.50 per ton, but varied widely depending upon quality and to some extent upon location.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

There are no known uranium or thorium deposits in the WSA or GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

There are no known thorium or uranium occurrences within the WSA or GRA. However, two occurrences have been noted in the Troy Mining district near the southwest corner of the GRA (see Uranium Land Classification and Mineral Occurrence Map). Anomalous radioactivity, associated with iron oxides along faults in quartzite near contacts with a quartz monzonite intrusive, has been noted at the Shoe Shoe mine and the First Strike prospect (Sec. 33, T 6 N, R 57 E) (Garside, 1973).

3. Mining Claims

There are many unpatented claims in the GRA but it is doubtful that any of these are for uranium or thorium.

4. Mineral Deposit Types

Uranium or thorium deposit types cannot be discussed due to the lack of deposits of these elements in the WSA and GRA.

5. Mineral Economics

Uranium and thorium appear to be of little economic value in the WSA or GRA due to lack of occurrences of these elements.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer of uranium (American Bureau of Metal Statistics, 1982). The United States ranks second behind Australia in uranium resources based on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound of concentrate.

Thorium is used in the manufacture of incandescent gas mantles, welding rods, refractories, as fuel for nuclear power reactors and as an alloying agent. The principal source of thorium is monazite which is recovered as a by-product of titanium, zirconium and rare earth recovery from beach sands. Although monazite is produced from Florida beach sands, thorium products are not produced from monazite in the United States. Consequently, thorium products used in the United States come from imports, primarily from France and Canada, and industry and government stocks. Estimated United States consumption of thorium in 1980 was 33 tons, most of which was used in incandescent lamp mantles and refractories (Kirk, 1980b). Use of thorium as nuclear fuel is relatively small at present, because only two commercial thorium-fueled

reactors are in operation. Annual United States demand for thorium is projected at 155 tons by 2000 (Kirk, 1980a). Most of this growth is forecast to occur in nuclear powr reactor usage, assuming that six to ten thorium-fueled reactors are on line by that time. The United States and the rest of the world are in a favorable position with regard to adequcacy of thorium reserves. The United States has reserves estimated at 218,000 tons of ThO_2 in stream and beach placers, veins and carbonatite deposits (Kirk, 1982); and probable cumulative demand in the United States as of 2000 is estimated at only 1,800 tons (Kirk, 1980b). The price of thorium oxide at the end of 1981 was $16.45 per pound.

Oil and Gas Resources

1. Known Oil and Gas Deposits

The Eagle Springs oil field (Locality #1) is located in the Railroad Valley portion of the GRA. There have been over a dozen wells that have produced oil since the discovery well drilled by Shell in the early 1950s. Depending on pricing, environmental and other conditions, there are normally fewer wells which produce. Oil from this field has been trucked to refineries in California and Utah.

Also in Railroad Valley, but outside the GRA are the Trap Spring (#2), Currant (#3) and Bacon Flat (#4) oil fields.

2. Known Prospects, Oil and Gas Occurrences and Petroliferous Areas

Most of the exploration and development wells in Railroad Valley have recorded oil and/or gas shows in the Tertiary and Upper Paleozoic sections. Drilling has been as deep as 13,831 feet with the A. Paul Sutherland, Sutherland No. 1 (#5). The wells shown give a good indication as to the continued interest in the area by the petroleum industry (Lintz, 1957; Schilling and Garside, 1968; Garside and others, 1977; Nevada Bureau of Mines and Geology, 1982).

3. Oil and Gas Leases

Federal leases cover nearly all the GRA and about half of the WSA, even in the mountains.

4. Oil and Gas Field Types

The Eagle Springs oil field produces from the Eocene Sheep Pass Formation, a freshwater limestone, and Oligocene volcanics. Some minor production has come from the Upper

Paleozoic Ely (?) Formation. The reservoir at Trap Spring is the Oligocene Garrett Ranch volcanics. Both are mainly fault trap controlled.

5. Oil and Gas Economics

The low level of production from Nevada Basin and Range oil fields, which are remote from existing pipelines, existing refineries and consuming areas, necessitates the trucking of the crude oil to existing refineries in Utah, California and Nevada. Since the discovery of oil in Nevada in 1953, the level of production has fluctuated. Factors which have affected the production from individual wells are: reservoir and oil characteristics; Federal regulations; productivity; environmental constraints; willingness or ability of a refiner to take certain types of oil; and of course, the price to the producer, which is tied to regional, national and international prices.

Geothermal Resources

1. Known Geothermal Deposits

There are no known geothermal deposits in the GRA.

2. Known Prospects, Geothermal Occurrences and Geothermal Areas

On the western margin of the Grant Range in the alluvium there are three thermal occurrences: Tom Spring (Locality #1) with 72° water and Blue Eagle Springs (#2) with water of 82°F, and an unnamed spring (#3) having water of 70°F.

On the other side of the range outside the GRA in White River Valley, there is a series of thermal springs (Garside and Schilling, 1979):

Locality Number	Site Name	Water Temperature (°F)
#4	Moorman Spring	100°
#5	Hot Creek Ranch Spring	92°
#6	Forest Moon Ranch Springs	89°
#7	Moon River Spring	92°

3. Geothermal Leases

There are no geothermal leases in the GRA, but six sections are under lease in Railroad Valley in the Bacon Flat oil field area.

4. Geothermal Deposit Types

Geothermal resources are hot water and/or steam which occurs in subsurface reservoirs or at the surface as springs. The temperature of a resource may be about 70°F (or just above average ambient air temperature) to well above 400°F in the Basin and Range province.

The reservoirs may be individual faults, intricate fault-fracture systems, or rock units having intergranular permeability -- or a combination of these. Deep-seated normal faults are believed to be the main conduits for the thermal waters rising from thousands of feet below in the earth's crust.

The higher temperature and larger capacity resources in the Basin and Range are generally hydrothermal convective systems. The lower temperature reservoirs may be individual faults bearing thermal water or lower pressured, permeable rock units fed by faults or fault systems. Reservoirs are present from the surface to over 10,000 feet in depth.

5. Geothermal Economics

Geothermal resources are utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year round mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (226°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is an historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

No other geological resources are known in WSA NV 040-166. There is no potential for coal or for oil shale.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

Tungsten, a strategic and critical mineral, has been produced in the GRA, from mines as close as one mile from the WSA.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES POTENTIAL

Huttrer (1963), Hyde (1963) and Kirkpatrick (1960) provide detailed geologic maps of the entire WSA at scales of 1:12,000 to 1:24,000; these are evidently the basis for the geology shown in the area by Kleinhampl and Ziony (1967). Kleinhampl and Ziony (1976) and Kral (1951) provide brief descriptions of what appear to be all old mines and prospects, as indicated by mine and prospect symbols on the topographic maps, while information from Mr. Paul Harley (see notes in GRA File) provides data on recent work near the north end of the WSA. Information concerning hydrothermal alteration in the WSA, if there is alteration, is lacking. The quantity and quality of geologic data is high, as is the quantity and quality of data pertaining to mineralization except for alteration if there is any. Overall, the level of confidence in the information available is high.

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g. M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C, and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside the WSA has been used in establishing a classification area within the WSA, then at least a part of the surrounding area may also be included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report.

In connection with nonmetallic mineral classification, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel, with moderate confidence, since alluvium is by definition sand and gravel. All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rock, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA NV 040-166

M1-2B. This classification area covers the entire WSA. The series of Paleozoic sediments exposed throughout the WSA includes several units that are known to be favorable for metal mineralization throughout the region. There is considerable structural complexity that can serve as conduits for mineralizing solutions -- thrust faulting in the southern part of the WSA, and closely-spaced steep faulting in the northern part are particularly noticeable (Kleinhampl and Ziony, 1967). The nature of the rocks and the complexity of the structure are the reasons for the classification of low favorability. The absence of known metallic mineral occurrences and of intrusive rocks that are likely sources of mineralizing solutions is the reason for the low level of confidence in this classification.

b. Uranium and Thorium

WSA NV 010-166

U1-2B. This land classification indicating low favorability for uranium with a low confidence level covers most of the WSA and portions of the northeast, north-central and southwest parts of the GRA. Most of the area is covered by Paleozoic sedimentary rocks, but the eastern parts of the area contain Tertiary volcanics, and a granitic intrusive is present in the southwestern corner of the GRA. The area has low favorability for fracture-filling uranium deposits in any of these rock types. The Tertiary volcanics are a possible source for uranium which could be remobilized by ground water and deposited along fractures in the volcanics or in the highly faulted and fractured Paleozoic sediments. Uranium could also be deposited in fractures in wall rocks at or near contacts with the granitic intrusive. Radioactive occurrences of this type have been noted near quartz monzonite in the Troy district southwest of the GRA as is discussed in the uranium occurrences section.

Most of the area has very low favorability for thorium with a low level of confidence. However, if pegmatites occur with the previously mentioned granitic intrusive, they may be a minor source of thorium in that area.

U2-2B. This land classification covers small areas on the margins of the WSA and the northwestern, southeastern, and parts of the northeastern portions of the GRA. The areas are covered by Quaternary alluvium and have low favorability at a low level of confidence for epigenetic

sandstone type uranium deposits. Tertiary volcanics on the east flank of the Grant Range and granitic intrusives in the southwestern part of the GRA are possible source rocks for uranium in the area. Uranium leached from these rocks by ground water and carried into permeable alluvium at the base of the mountains could be deposited where ground water encounters reducing conditions.

The area has low favorability at a very low level of confidence for thorium only in the southwest corner of the GRA, where granitic intrusives which may contain pegmatites are a possible source for thorium which can occur in placer concentrations in the alluvium adjacent to the intrusive outcrops. The rest of the area has very low favorability for thorium at a low confidence level.

c. Nonmetallic Minerals

WSA NV 040-166

N1-3C. This classification area covers most of the WSA. In it are exposed Paleozoic limestones and dolomites that are mineable as raw materials for lime, cement and other industrial applications. The presence of the rocks is known; this is the reason for the classification as moderately favorable. The quality of the limestones and dolomites are not known; this is the reason for the only moderate level of confidence in the classification.

N2-3C. This classification area covers part of the eastern edge of the WSA. In it is mapped Quaternary alluvium, which by definition contains sand and gravel. While sand and gravel are known to be present, the quality of it at any point is not known; this is the reason for the classification as moderately favorable with a moderate level of confidence.

N3-3C. This classification area covers a small part of the western edge of the WSA, in which Quaternary alluvium is mapped. The rationale for the classification and level of confidence is the same as for N2-3C.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA NV 040-166

OG1-2A. Those valley portions of the WSA which are underlain by valley sediments and widely dispersed Tertiary volcanics have low favorability since there is a chance that prospective strata (post-Lower Paleozoic age) strata may be present. Leases cover these areas.

OG2-1A. This classification is reserved for the Grant Range proper. Here Lower Paleozoic rocks crop out or are covered by only a thin veneer of alluvium. These rocks are stratigraphically lower than the prospective horizons currently anticipated.

b. Geothermal

WSA NV 040-166

G1-2A. This small portion of the WSA is in the Railroad Valley/range front area which is similar to the geologic environment that is host to the three thermal occurrences to the north. The area is also adjacent to the geothermal leased area at Bacon Flat oil field.

G2-1A. This classification covers the remaining major part of the WSA. The range front and major valley faults which host the thermal and cool springs in this region are far removed from the eastern flank of the Grant Range and the WSA.

c. Sodium and Potassium

S1-1D. There is no known potential for sodium or potassium in WSA NV 040-166, and the entire WSA is classified as low favorability with high confidence for these elements. No land classification map is presented for sodium and potassium.

3. SALEABLE RESOURCES

Saleable resources have been considered in connection with nonmetallic minerals.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

The geochemical evidence for possible disseminated gold mineralization at the Well claims suggests that there may be similar sites within the WSA. At least the thrust fault in the southern part of the GRA, and the structurally complex area in the northern part, should be reconnoitered and perhaps sampled to determine if there is any evidence of silicification or other alteration that might indicate such mineralization. It would be better to reconnoiter the entire WSA.

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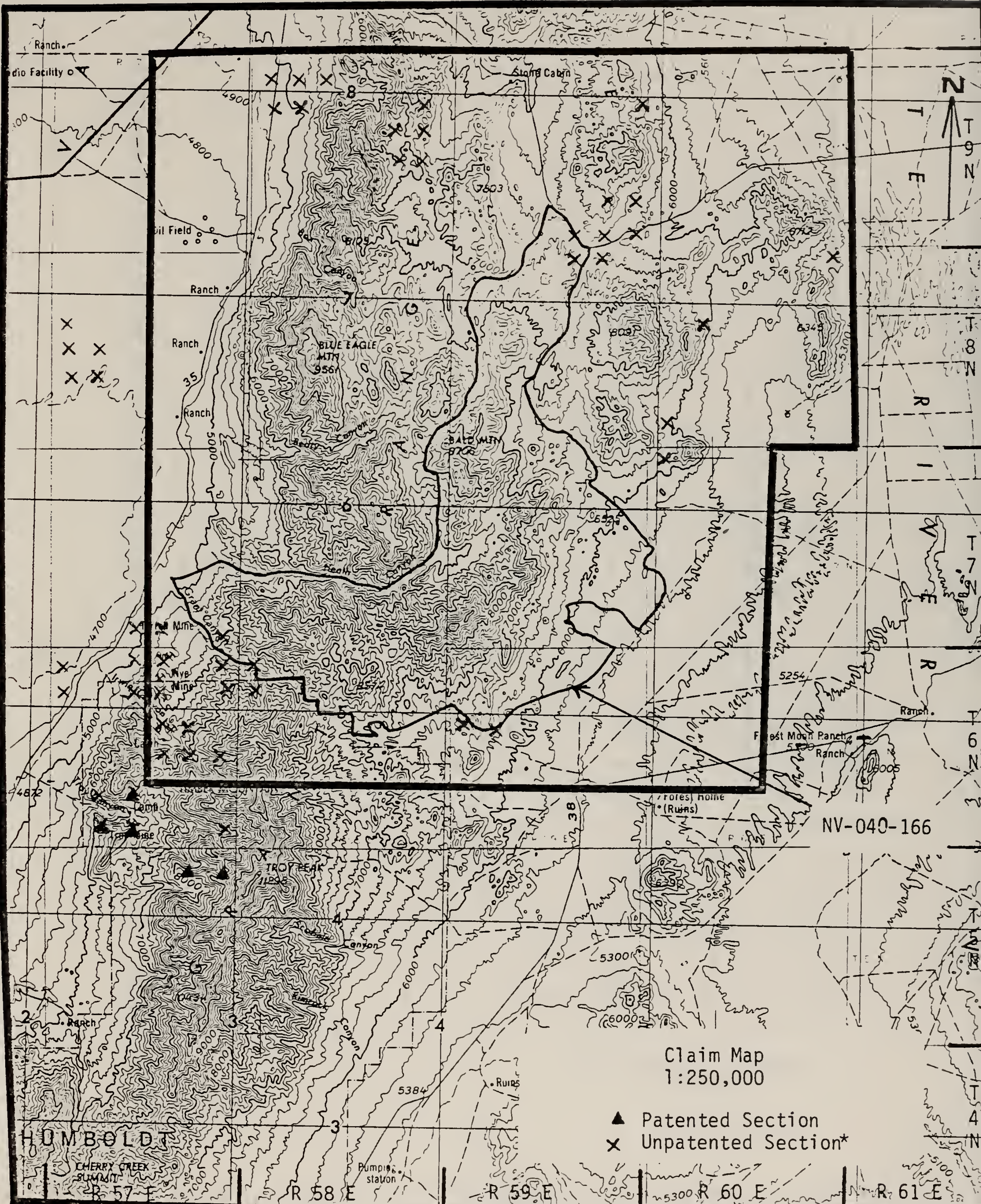
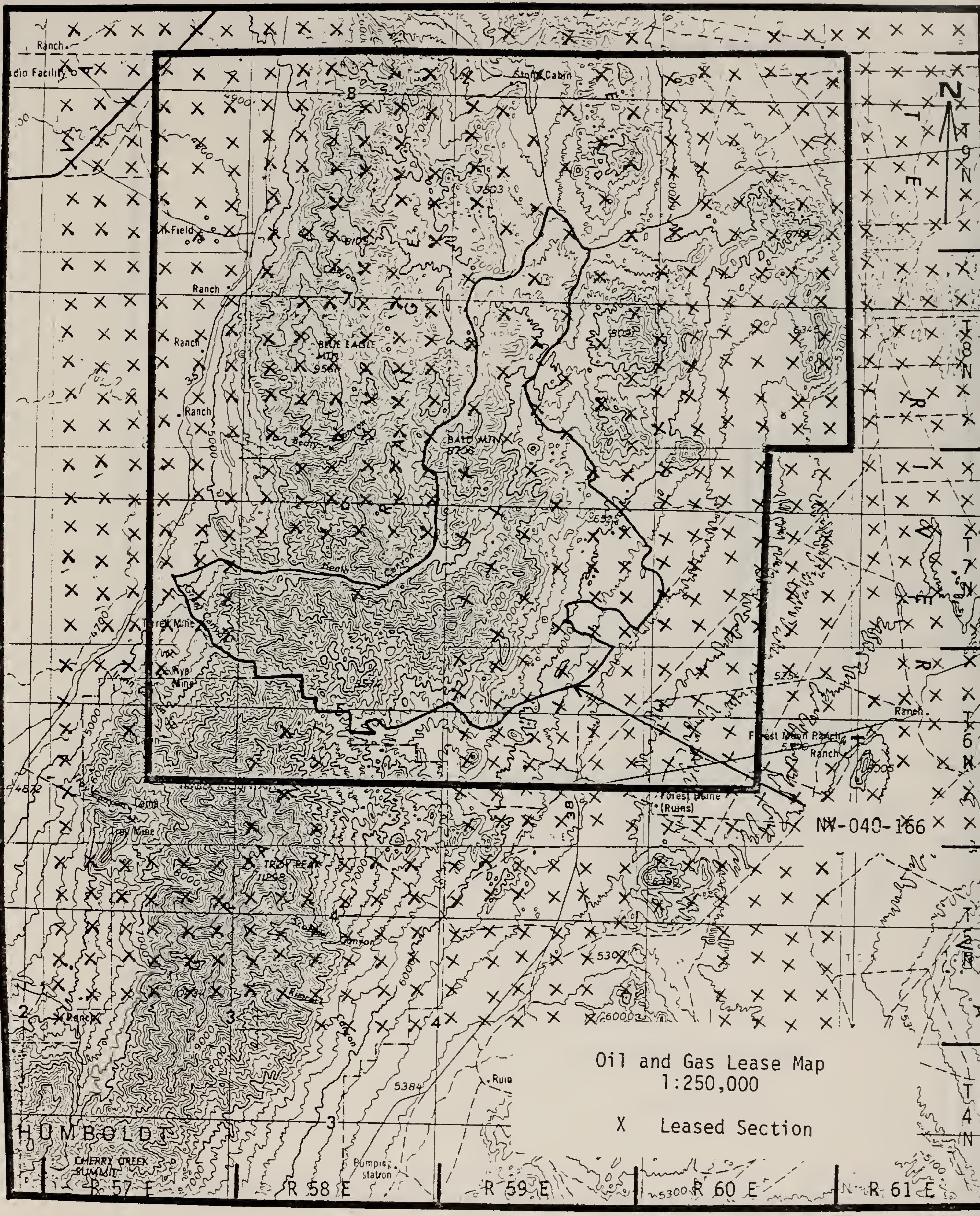
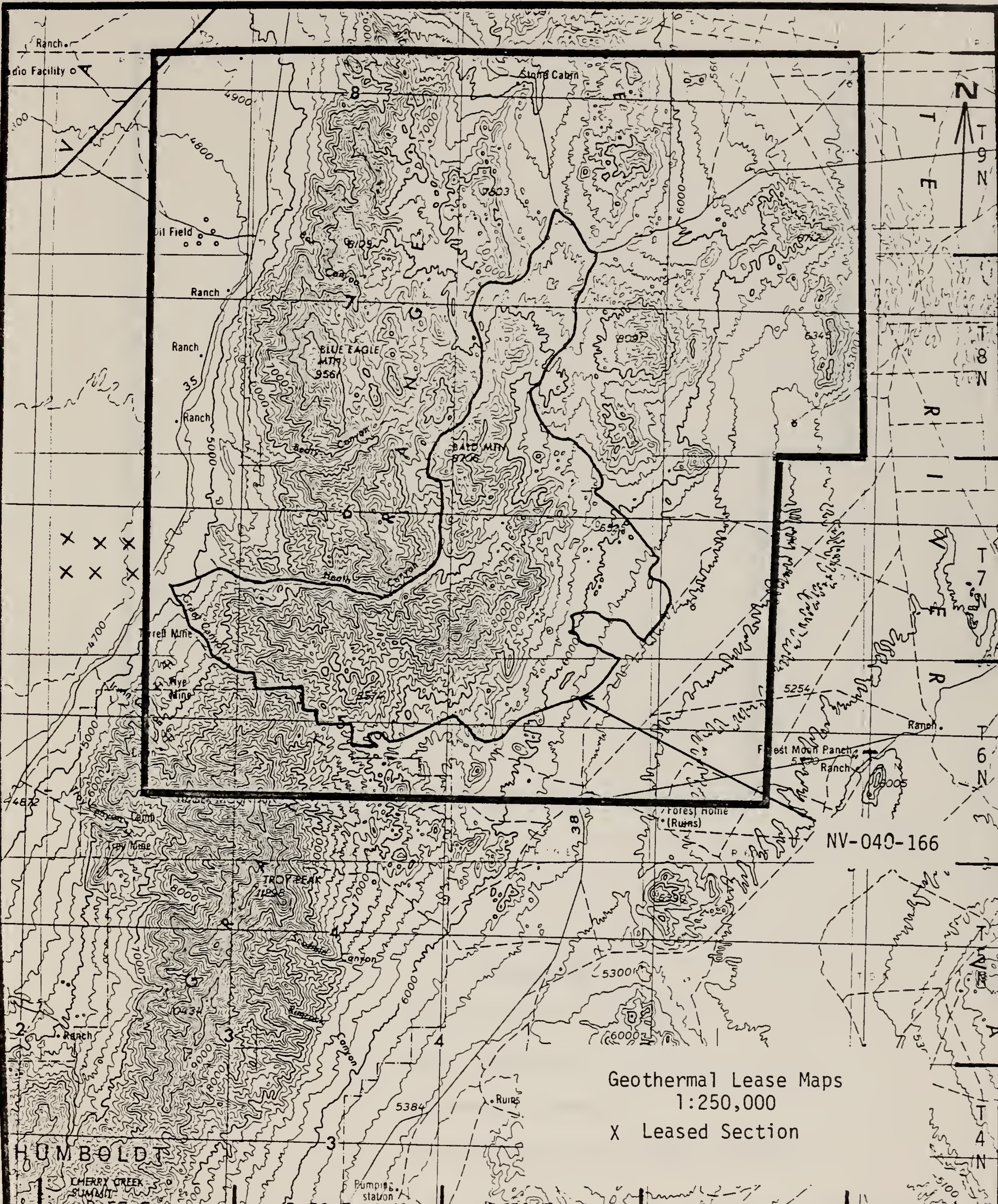


*X denotes one or more claims per section

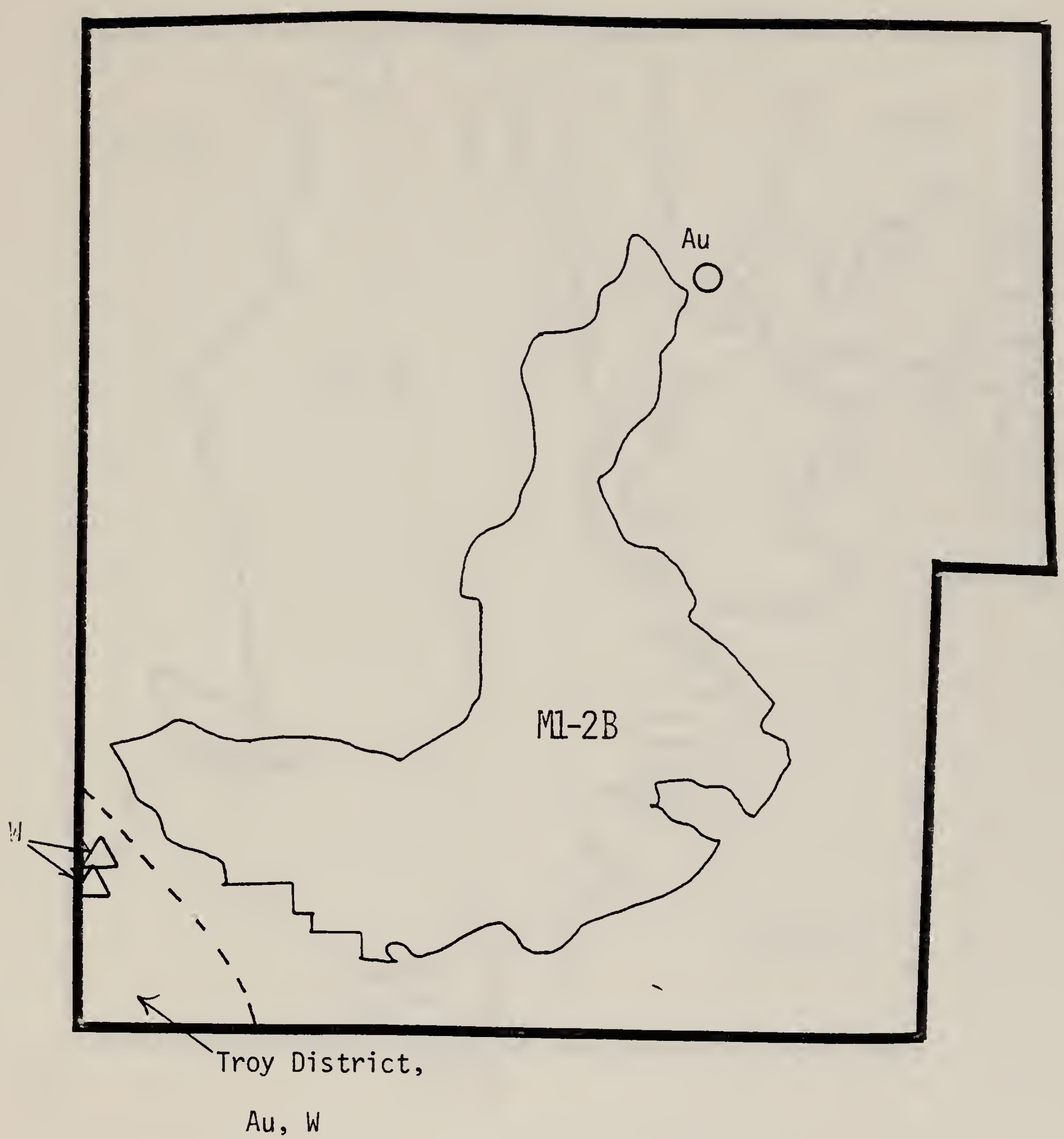
Riordan's Well GRA NV-13
Scale 1:250,000



Riordan's Well GRA NV-13
Scale 1:250,000



Riordan's Well GRA NV-13
Scale 1:250,000



EXPLANATION

- - - - Mining District, commodity

△ Mine, commodity

○ Occurrence, commodity

—— WSA and Land Classification Boundary

Land Classification - Mineral Occurrence Map/Metallics

Riordan's Well GRA NV-13
Scale 1:250,000

EXPLANATION

● Uranium Occurrence

▬ Land Classification Boundary

— WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium

Riordan's Well GRA NV-13
Scale 1:250,000

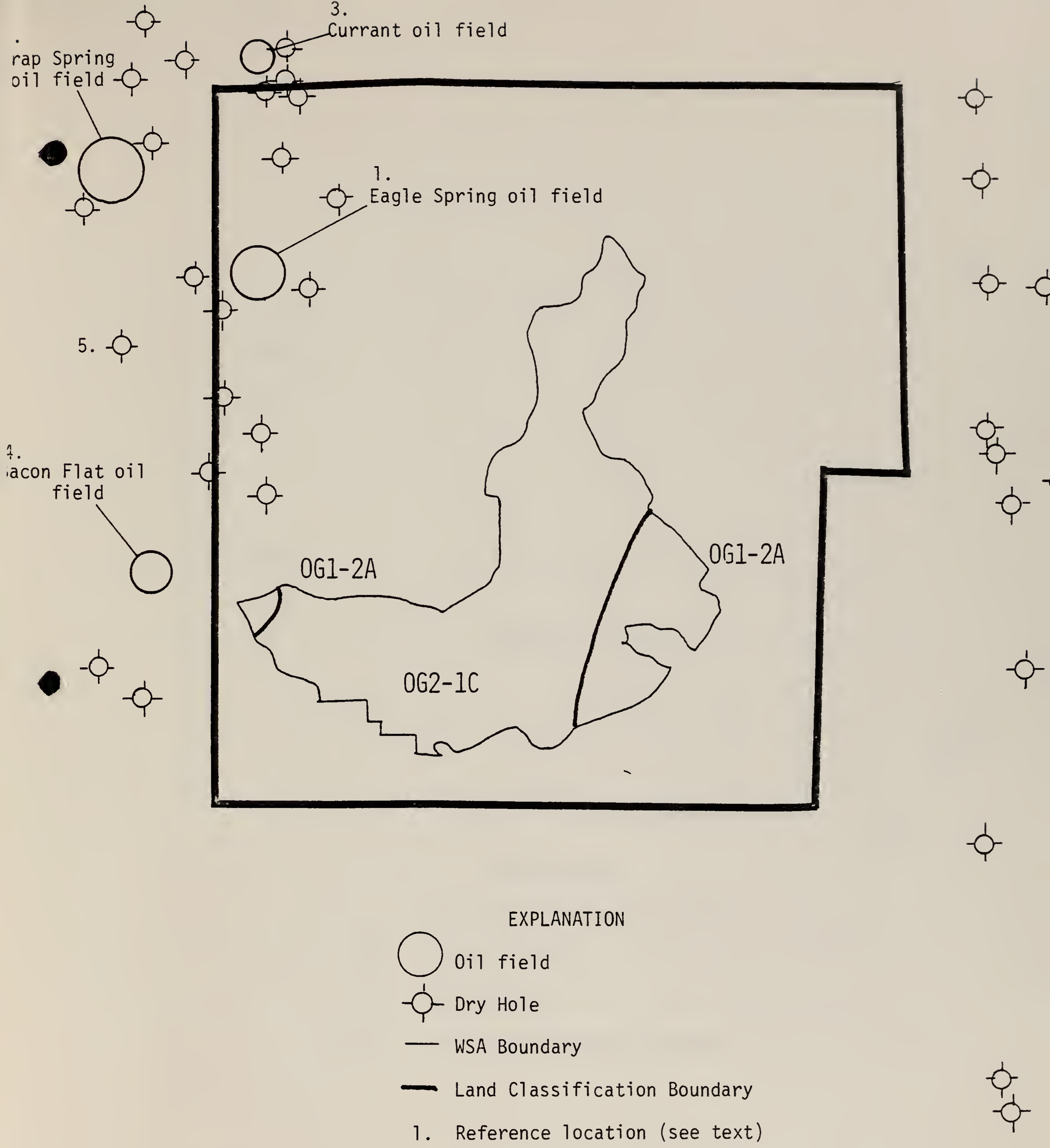
EXPLANATION

Land Classification Boundary

WSA Boundary

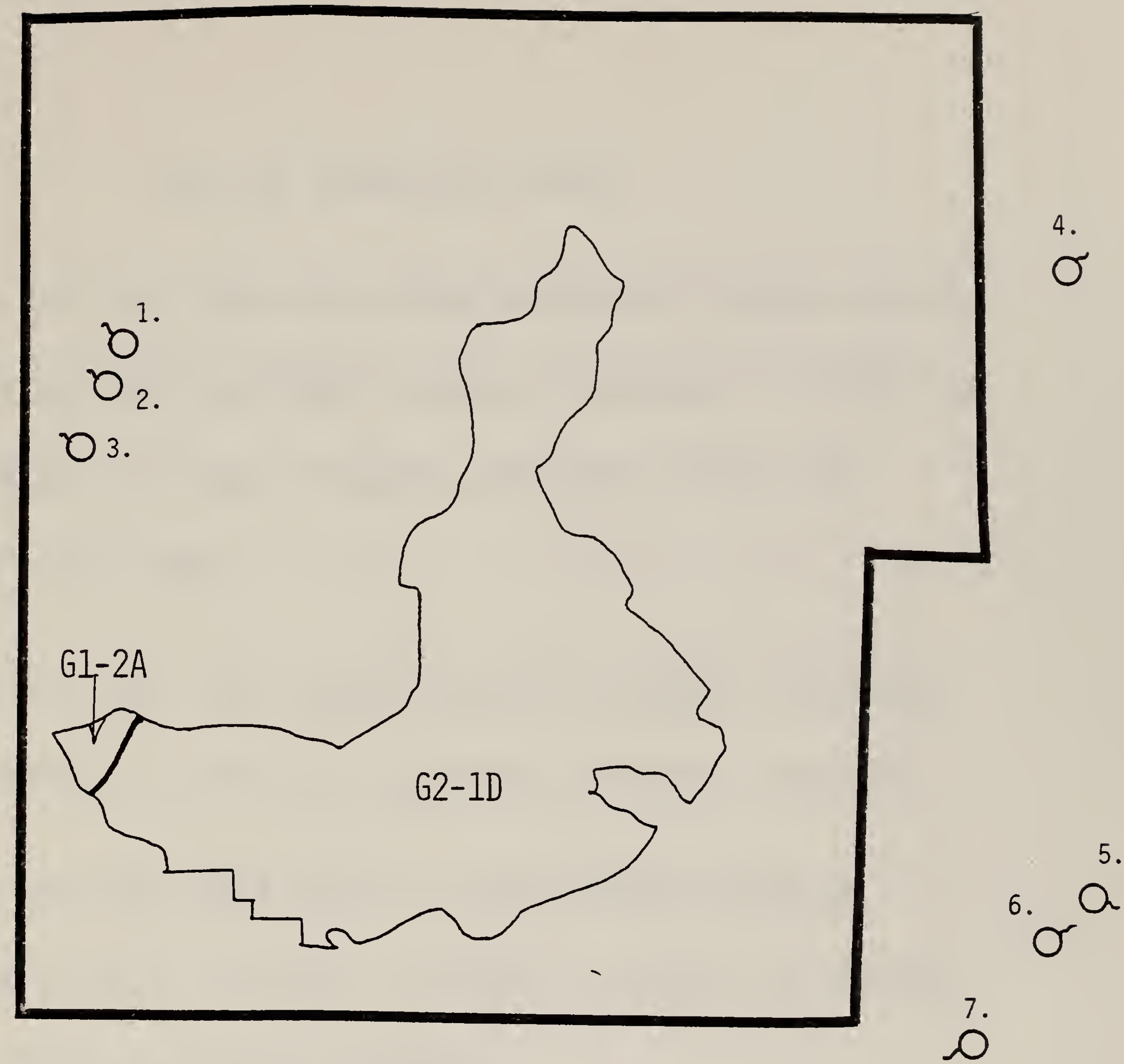
Land Classification - Mineral Occurrence Map/Nonmetallics

Riordan's Well GRA NV-13
Scale 1:250,000



Riordan's Well GRA NV-13
Scale 1:250,000

Land Classification - Mineral Occurrence Map/Oil and Gas



EXPLANATION

1. Reference location (see text)

Thermal Spring

WSA Boundary

Land Classification Boundary

Land Classification - Mineral Occurrence Map/Geothermal

Riordan's Well GRA NV-13
Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period		Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary		Holocene	
			Pleistocene	2-3 [1]
	Tertiary		Pliocene	12 [1]
			Miocene	26 [2]
			Oligocene	37-38
			Eocene	53-54
			Paleocene	65
Mesozoic	Cretaceous [4]		Upper (Late) Lower (Early)	136
	Jurassic		Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic		Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]		Upper (Late) Lower (Early)	280
	Carboniferous Systems	Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
		Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian		Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]		Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]		Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]		Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [3]			Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600 + [3]

[1] Holmes, Arthur, 1965, Principles of physical geology: 2d ed., New York, Ronald Press, p. 360-361, for the Pleistocene and Pliocene; and Obradovich, J. D., 1965, Age of marine Pleistocene of California: Am. Assoc. Petroleum Geologists, v. 49, no. 7, p. 1087, for the Pleistocene of southern California.

[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.

[3] Stern, T. W., written commun., 1968, for the Precambrian.

[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

GEOLOGIC NAMES COMMITTEE, 1970